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SUBJECT:	**Mercury Action Example**
NUMBER OF PAGES (including transmittal page):	**8**

NOTES:

Hi Rick - At long last, I am finally forwarding you a draft action regarding mercury for your consideration. I have e-mailed you an electronic copy as well as this fax.
This action is intended to provide an example of how we believe the action strategies comprising CALFED's Water Quality Common Program could be fleshed out in greater detail to provide the reader with both a better context within which to consider the action (including a problem statement and discussion of existing programs) and greater specificity regarding the intended action strategy itself. As we have discussed, we would like to see the actions comprising the common program revised in a similar fashion.

This mercury action is clearly a work-in-progress; there are still gaps to be filled and refinements needed (particularly under existing activities, action plan, performance measures and indicators of success). While this is not what I consider a "finished" product, I still want to get it to you now for your consideration. I apologize for the delay in getting this example to you. As I mentioned last week, we are working on two other actions (one drinking water-related and the other regarding selenium) that I hope to get to you in mid-January. I also intend to continue to refine this action statement.

I am going to be out of the office for the last two weeks of December. Perhaps we could meet or talk by phone in early January about this approach and next steps? I welcome your feedback in the meantime. Happy Holidays!

Gail

SENDER: **Gail Louis**

DATE: **12/18/97**

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DRAFT 12/18/97

ACTION 2 - MINE DRAINAGE - HG

Problem Statement: Mercury has been found throughout the San Francisco Bay-Delta estuary at elevated concentrations in water, sediment and organisms. Mercury is of concern from both an environmental and human health perspective. Effects on fish include death, reduced reproductive success, impaired growth and development, and behavior abnormalities. Mercury exposure in birds can cause reproductive effects, in plants can cause death and sublethal effects.(5) The direct and additive effects of mercury within the estuary on reproduction, development and juveniles of aquatic and aquatic-feeding species is poorly understood.

In general, mercury accumulates up aquatic food chains so that organisms in higher trophic levels have higher mercury concentrations. High mercury levels in sport and recreational fish has rendered certain fish inedible. Mercury (in the form of methyl mercury) poses a serious concern to human health as it accumulates in tissue, bioaccumulates within the food web, and is a potent neurotoxin in humans. Fish found at the top of the food web can exhibit mercury tissue concentrations over one million times the mercury concentration of the surrounding water. (6) Mercury can cause nervous system damage in developing fetuses, as well as in children and adults.

In 1986, the Central Valley Regional Water Quality Control Board (Regional Board) surveyed mercury contamination in fish and sediment within the Sacramento River watershed. The Regional Board detected elevated mercury levels in sediment in the Yuba and Bear Rivers, and in Cache, Putah, and Stony Creeks. Fish captured in certain tributaries contained mercury levels that exceeded that 1973 National Academy of Sciences guidelines to protect aquatic resources and their predators. The Regional Board has also determined that mercury has caused the impairment of aquatic habitat beneficial use of the Sacramento River between the Colusa Basin Drain and the Delta. (1)

The State Water Resources Control Board (State Board) biennial water quality assessment lists 48,000 acres of Delta waterways as impaired because of fish consumption advisories for mercury. (3) Water bodies (or segments) included on the Clean Water Act Section 303(d) impaired Water bodies list due to mercury levels include: Delta waterways, Marsh Creek; in the Sacramento River watershed - the lower American River, Cache Creek, the lower Feather River, Harley Gulch, Humbug Creek, the Sacramento River (from Red Bluff downstream to the Delta), Sacramento Slough, Sulfur Creek; in the San Joaquin watershed - Panoche Creek, Salt Slough, and San Carlos Creek. (3)

In 1973, the California Department of Health Services issued a health advisory advising that pregnant women and children should not consume striped bass taken from the Bay-Delta estuary due to high mercury levels. (1)

A 1994 fish tissue contamination study revealed mercury concentrations in fish tissue at levels above those recommended as protective of human health in several species analyzed. Based upon the results of this study (and the levels of mercury as well as of other contaminants of concern), in December 1994, the California's Office of Environmental Health Hazard Assessment issued advisories concerning consumption of fish caught from the Bay. Specifically, adults were advised to limit consumption of sport fish from the Bay to two times a month; pregnant or nursing women and children 6 or under should limit consumption to one time a month. Further, large shark and striped bass from the Bay should not be consumed at all. (2)

In general, large-scale, systematic samplings of a variety of fish species have not been conducted in the Bay. Proper protection of the public from mercury contamination requires carefully validated studies of which types of fish are most likely to be contaminated and which are not. These studies have not been conducted.

In a 1997 report, UC Davis reported finding elevated mercury levels in the aquatic food webs of the South and Middle forks of the Yuba River, the mid-section of the Middle Fork of the Feather River, Deer Creek, the north fork of the Cosumnes River, and tributaries throughout the Bear River drainage. (4)

Sources of Mercury:

Mercury occurs naturally within the environment in a variety of forms including elemental mercury (Hg^0 or quicksilver), dissolved in rainwater (Hg^{+2}), as the ore cinnabar (HgS) and as methyl mercury ($HgCH^3$), an organo-metal. Mercury can undergo biological and chemical reactions which causes it to change form, altering its solubility, toxicity and bioavailability. Toxicity depends primarily upon the particular form of mercury.

Methylation of mercury is a key step enabling the entrance of mercury into food chains. Nearly 100% of the mercury that bioaccumulates in fish tissue is methylated. (5) The biotransformation of inorganic mercury into methylated organic mercury in water bodies occurs in both the sediment and the water column. There are many factors that affect the formation of methylated mercury, including pH, temperature, oxygen/redox level, salinity, toxicity, rate of sediment deposition, rate of pore water transvection, rate of mercury deposition, species of mercury deposited, and the rate of methyl mercury removal by bioaccumulation. (6)

Within the San Francisco Bay-Delta estuary (and, indeed, anywhere on earth), there is natural mercury contamination through atmospheric transport. Natural sources include volcanic releases, forest fires and oceanic releases. Unfortunately, little is known about the size of the contribution from natural versus human-made sources of mercury to the estuary.

There is a wide assortment of anthropogenic sources of mercury. Mercury has been used globally in many industrial, agricultural and domestic applications. For example, mercury is used in such products and processes as barometers, thermometers, mercury arc lamps, switches, fluorescent lamps, mirrors, catalysts for oxidizing organic compounds, gold and silver extraction from ores, rectifiers, cathodes in electrolysis/electroanalysis, in the generation of chlorine and caustic paper processing, batteries, dental amalgams, as a laboratory reagent, lubricants, caulks and coatings, in pharmaceuticals as a slimicide, in dyes, wood preservatives, floor wax, furniture polish, fabric softeners, and chlorine bleach. Human-related sources of mercury include fossil fuel combustion, production of chlorine and caustic soda at chlor-alkali plants, waste incineration, industrial discharges flowing through sewage treatment plants, mines and mining activities, smelters, and mercury spills from naval vessels. (6)

Mining-related activities are known to be a significant source of mercury within the estuary. The California Coast Range, on the west side of the Sacramento Valley, contains a large deposit of cinnabar; mines in this area supply the majority of mined mercury in the U.S. During the late 1800s and early 1900s, mercury was intensively mined from the Coast Range and subsequently transported across the Central Valley to the Sierra Nevada for use in placer gold mining operations. The majority of Coast Range mercury mines are now abandoned and remain unreclaimed. Some of the best known mercury mines are found in the Cache Creek and Lake Berryessa drainages in the Sacramento River watershed, in _____ (New Idria mine) in the San Joaquin River watershed, in the Marsh Creek watershed in the Delta (Mt. Diablo Mine), and in the South Bay watershed (New Almaden mining district). In addition to the active and abandoned mercury mines, there are also many unmined mercury deposits (in the form of cinnabar or HgS) throughout the Coast Range.(6)

The mercury employed in gold mining in the Sierra Nevada was refined liquid quicksilver or elemental mercury. Virtually all of the mercury brought to the Sierra Nevada for gold mining was ultimately lost into Sierran watersheds; once back in the environment, this elemental mercury likely underwent various transformations into different forms. The Central Valley Regional Board has estimated that approximately

7,600 tons of refined quicksilver were deposited in the Mother Lode region alone during the Gold Rush mining era. Mercury was also used in the northwestern and central Sierra Nevada for gold mining. (6)

Much of the mercury utilized by gold mining could have been incorporated into the 12 billion cubic meters of sediments extracted by the mining activities and released to the rivers of the Bay-Delta watershed. Studies by U.C. Davis and, more recently, the US Geological Survey (USGS) show that the sediments mobilized by hydraulic mining were ultimately transported to the Bay-Delta where they formed marshes and islands, or were deposited in shallow water sediments. Some of these potentially mercury contaminated areas are now areas being considered for habitat restoration through CALFED's Ecosystem Restoration Program Plan. USGS studies show that mercury concentrations in bay sediments containing hydraulic mining debris range from 0.3 to >1 ug/g. More importantly, these sediments contain mercury in its most reactive forms. Flooding or disturbing such sediments could inadvertently increase the amount of methyl mercury in the Bay ecosystem (i.e. uninformed restoration activities could augment the mercury contamination of bay fish). Numerous instances of accelerated methylation have occurred when sediments were flooded for reservoirs elsewhere, even in the absence of the type of mercury contamination found in hydraulic mining debris.

In summary, there is extensive bulk mercury contamination on both sides of the Central Valley - primarily hydraulic mining debris on the eastside and active and abandoned mines on the westside. (6) Cumulatively, these activities have resulted in the deposition of significant amounts of mercury in sediments of the Bay-Delta system. The potential exists that flooding or disturbing these sediments could accelerate methylation of that mercury and exacerbate mercury contamination of the Bay food web. Research is needed to determine they methylation capability of Bay sediments, particularly those sediments that originated from hydraulic mining activities.

Research can also lead to unexpected solutions to the mercury problem. For example, recent water quality data indicate that a significant amount of mercury from the gold mining era still exists in the sediment of the Upper Yuba River watershed, which is then transported downstream into the Engelbright Reservoir, where it is largely contained. Bioavailability studies reveal that the reservoir intercepts both inorganic, sediment-based mercury as well as bioavailable methyl mercury. While elevated mercury levels have been found upstream and in the reservoir, aquatic organisms taken from below the dam consistently demonstrate lower levels of mercury than those organisms in the reservoir or upstream. This suggests that the reservoir serves as an interceptor of bioavailable mercury, preventing it from being transported downstream to the estuary. This may also mean that much of the mercury in the Sierra Nevada remaining from gold mining activities, at least that originating upstream in dammed tributaries, may be trapped in foothill reservoirs and prevented from reaching the estuary. (6) However, mercury bioaccumulation in these reservoirs may pose localized health risks.

Recent studies suggest that the Coast Range may be a more significant contributor of mercury loadings to Central Valley rivers and the estuary than the Sierra Nevada. However, the relative contribution of these loads to mercury bioaccumulation, compared to the more reactive mercury from the Sierra side of the Valley is unknown.

Monitoring indicates that significant loading of metals to the estuary occur during high flow conditions. Sampling in the Sacramento River performed in January 1995 - during a peak storm period - by the Central Valley Regional Board detected high mercury concentrations in the Yolo Bypass. (Water from the Sacramento Valley entered the estuary via both the Sacramento River and the Yolo Bypass during this storm period.) Further investigation determined that Cache Creek (which drains Clear Lake, an area with several mercury mines) appears to be a significant source of mercury discharging into the Bypass (and ultimately into the Delta) during heavy runoff events. (2) Cache Creek was estimated to have exported about a thousand kilograms of mercury to the estuary in 1995. (6) High mercury levels were also found in the Sacramento River upstream of the confluence with the Feather River.

Another watershed with high mercury levels is the Marsh Creek watershed, located in Contra Costa County. Studies conducted in 1995 determined that this relatively small watershed exported 10 - 20 grams of mercury per day, with greater amounts during storm events. These studies also suggest that about 95% of the mercury load in the watershed originated from the Mount Diablo mining area, with 93% coming from a "small" area of exposed mine tailings. (6)

Mercury transported from these watersheds is deposited in the Bay-Delta. Depositional areas ranging from the Yolo Bypass to Suisun Marsh have the potential to be hotbeds of mercury methylation and may, in fact, be a more significant source of the methyl mercury found in fish than is the new mercury coming from the mines. Mercury in sediment may be resuspended through bioturbation, wave action, dredging activities and disposal, and flooding of lands. The chemical form of mercury in the sediment and environmental conditions at the time of release will affect the bioavailability of the reintroduced mercury.

Determining the relative contributions of the various sources (mercury mines, hydraulic mining debris, recycling from depositional areas) to the primary problem (methyl mercury in fish) is necessary to developing cost-effective solutions to the system's mercury problems.

Existing Activities/Efforts:

Section 303(d) of the 1987 Clean Water Act requires states to identify water bodies that are impaired with respect to water quality (where beneficial uses are not attained). Statewide, 33 waters were listed on 1996 303(d) list due mercury impairment; 18 were located within the Central Valley Regional Board's jurisdiction; 6 within the San Francisco Bay Regional Board's area. Most listings are associated with mining and resource extraction. ***(Discussion of TMDL process for water-quality limited segments)***

RWQCB mine discharge abatement activities:

Regulation of Mines - ***(Chapter 15 sites - how relates to NPDES?)*** The Central Valley Regional Board regulates active and inactive mines under its Waste Discharge program, the National Pollutant Discharge Elimination System (NPDES) permitting program, and on an individual basis. Operators of active mines are required to obtain permits for any discharges, which limit releases to only inert or non-hazardous wastes.

Abandoned mines generally constitute a greater threat to water quality than do active mines. Inactive and/or abandoned mines frequently lack a responsible party who will initiate remediation and assume financial responsibility. Limited resources and concerns over liability have traditionally inhibited agencies' ability to address inactive mines.

Sulphur Bank Mercury Mine, located near Clear Lake in the Cache Creek watershed, is a federal Superfund site. ***(specifics on site status)***

US EPA contractors have conducted a Preliminary Assessment and Site Investigation of the New Idria Mine site, as a first step in considering whether to add the New Idria mine site to the National Priorities List (NPL). Sites identified on the NPL fall under the authorities of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) for remediation.

California Department of Conservation's Division of Mines and Geology maintains a database on abandoned mines in the State. ***Other activities?***

Cache Creek Watershed Project - The Colorado Center for Environmental Management received a grant from US EPA to organize stakeholders in the Cache Creek watershed to develop a comprehensive

watershed management plan.

Sacramento River Mercury Control Planning Project - This project, using grant funding from US EPA, has developed a proposed implementation plan for control of mercury from both point and nonpoint sources within the Sacramento River watershed. The draft plan calls for several source control strategies: reclamation of mine tailings, removal of mine tailings, removal of instream mercury-enriched sediments, changes in the operation of reservoirs and dredging of mercury-rich sediments in major reservoirs, treatment of mine drainage, additional regulation of gold mining operations, and a mercury recycling program. (1)

USGS NAWQA study on Sacramento River & metals transport study
The USGS has developed an unambiguous method for identifying deposits of hydraulic mining debris and begun to survey mercury concentrations in that debris. USGS has also submitted proposals for Category 3 funding to begin studying methylation processes in different types of habitats in the Bay-Delta, as well as the food web transfer of mercury, so as to identify the species most likely to be contaminated by mercury.

UC Davis research - Davis Creek reservoir, Marsh Creek watershed, bioavailability
Researchers from UC Davis have determined that fish tissue concentrations can be predicted from lower trophic level invertebrate concentrations.

Pilot Mercury Recycling Program - The Central Valley Regional Board and State Water Resources Control Board are developing a pilot mercury recycling program, based upon existing hazardous waste recycling programs. The program includes a public outreach and education component, fostering a cooperative relationship with the gold mining community (both recreational and commercial), and establishing the infrastructure for collecting and transporting recovered mercury to commercial recyclers. (1)

In December 1997, some CALFED Category 3 restoration funds were directed toward evaluating the effects of wetland restoration on methyl mercury production in the estuary. This three-year study will quantify changes in methyl mercury production caused by restoration activities and evaluate the availability and impact of mercury of the Bay-Delta ecosystem. The results of this work will be used to direct longer-term ecosystem restoration activities to minimize methyl mercury production.

Action Plan / Strategy: The reduction and eventual elimination of mercury fish tissue advisories will require implementation of a multi-pronged approach that includes the following elements: (1) establishment of a task force to facilitate information exchange and develop a regional mercury strategy; (2) source identification and assessment studies in the Central Valley and San Francisco Bay area; (3) directed research to better understand mercury cycling in the Central Valley and estuary; (4) carrying out pilot mercury control projects and evaluating their effectiveness; and, integrating the previously mentioned elements, (5) development and implementation of a regional mercury control strategy.

- Form a regional mercury control strategy task force. The Task Force should include scientists, watershed stakeholder representatives, and resource managers from both the Central Valley and San Francisco Bay area. The task force should assist in defining research needs, refine assessment and source identification studies, review proposed control strategies, assist in the development of policy for the implementation of control strategies, and serve as a clearinghouse for mercury-related information. The Task Force should be empowered to make recommendations to the CALFED Implementation Entity and other entities for possible funding.

- Conduct source identification and assessment activities - specifically, continue mercury loading and bioavailability studies and conduct fish tissue burden studies to evaluate the risk to public health of elevated mercury concentrations. (A) Continue mercury mass load studies in the Central Valley with an emphasis on watersheds where no data are available. These should include the

San Joaquin, Mokelumne and Cosumnes Rivers. Detailed followup studies should be undertaken in watersheds which initial studies identify as the major sources of mercury. Follow-up studies should include an assessment of interannual variability and the precise location of mercury sources. The studies should also include assessments of the load contributions from major NPDES and stormwater discharges. The mass load work should be accompanied by biological surveys to identify locations with enhanced food chain mercury bioavailability. (B) Undertake mercury fish tissue studies in all major reservoirs and watercourses on the east and west side of the Valley and in the Delta. Studies should be designed and carried out in coordination with the Office of Environmental Health Hazard Assessment, Department of Health Services, and Department of Fish and Game. A primary purpose is to establish the public risk posed by consumption of fish with elevated mercury levels. Angler fish consumption studies should be conducted in locations with elevated mercury to identify high risk groups and aid in development of fish advisories. Encourage watershed groups to conduct public outreach and education programs, targeting high risk groups. A secondary objective of these fish tissue studies is to establish baseline conditions to evaluate the future success of control efforts.

- Undertake directed research to better understand mercury cycling in the Central Valley and estuary. Research should focus on evaluating the relative bioavailability of the different sources of mercury entering the estuary, as compared to the bioavailability of mercury already present in the estuary and sediments. These studies should include an evaluation of inputs from the Coast Range, Sierra Nevada mountains, and municipal, industrial and stormwater discharges. Studies should also evaluate the importance of the remobilization of mercury resulting from dredging activities, disposal of dredged material on island levees, and habitat creation. Research should also determine the effects of creating shallow water and marsh habitat on methyl mercury production in the estuary. The ultimate purpose of the directed research component is to provide resource managers with recommendations on how to minimize mercury bioaccumulation in the Central Valley, Delta and San Francisco Bay.

- Develop and carry out pilot control studies to ascertain the most practical, cost-effective method of minimizing mercury bioaccumulation. These pilot studies should integrate improved knowledge regarding mercury cycling and identification of the primary sources of bioavailable mercury. Pilot-scale projects could target Cache Creek watershed, Mount Diablo Mine, or areas generally identified as a primary source of bioavailable mercury.

- Develop and implement a long-term, regional mercury control strategy. The strategy should address and prioritize for action the various sources of mercury contamination in the estuary, including point sources (active and abandoned mines, wastewater discharges), mercury-laden runoff from upper watershed areas, and contaminated sediments. Strategy should also utilize local watershed groups and Task Force to help prioritize and assist in carrying out mercury control projects. The strategy should also identify resource needs and funding strategy for implementation.

Performance Measures: Link interim performance measures to improved understanding of mercury methylation processes and mercury cycling in ecosystem, identification and remediation of sources of bioavailable mercury entering the estuary,

Achievement of US EPA 304(a) guideline for mercury in the Delta and its tributaries.

Indicators of Success: Lower methyl mercury concentrations in fish and sediments.
Elimination of fish advisories for mercury.

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